National Aeronautics and Space Administration

Ares V Overview

presented at

Ares V Solar System Science Workshop
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www.nasa.gov

Introduction

- The NASA Ares Projects Office is developing the launch vehicles to move the Nation beyond low earth orbit
- Ares I is a crewed vehicle, and Ares V is a heavy lift vehicle being designed to place cargo on the Moon
- This is a work-in-progress and we are presenting a "snap-shot" of the ongoing effort
- The Ares V vehicle will be considered a national asset, and we look forward to opening a dialogue for potential applications with the solar system exploration community
- Our goal today is to introduce you to the Ares V vehicle
  - Mission and Vehicle Overview
  - Performance Description

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Ares V Mission and Vehicle Overview

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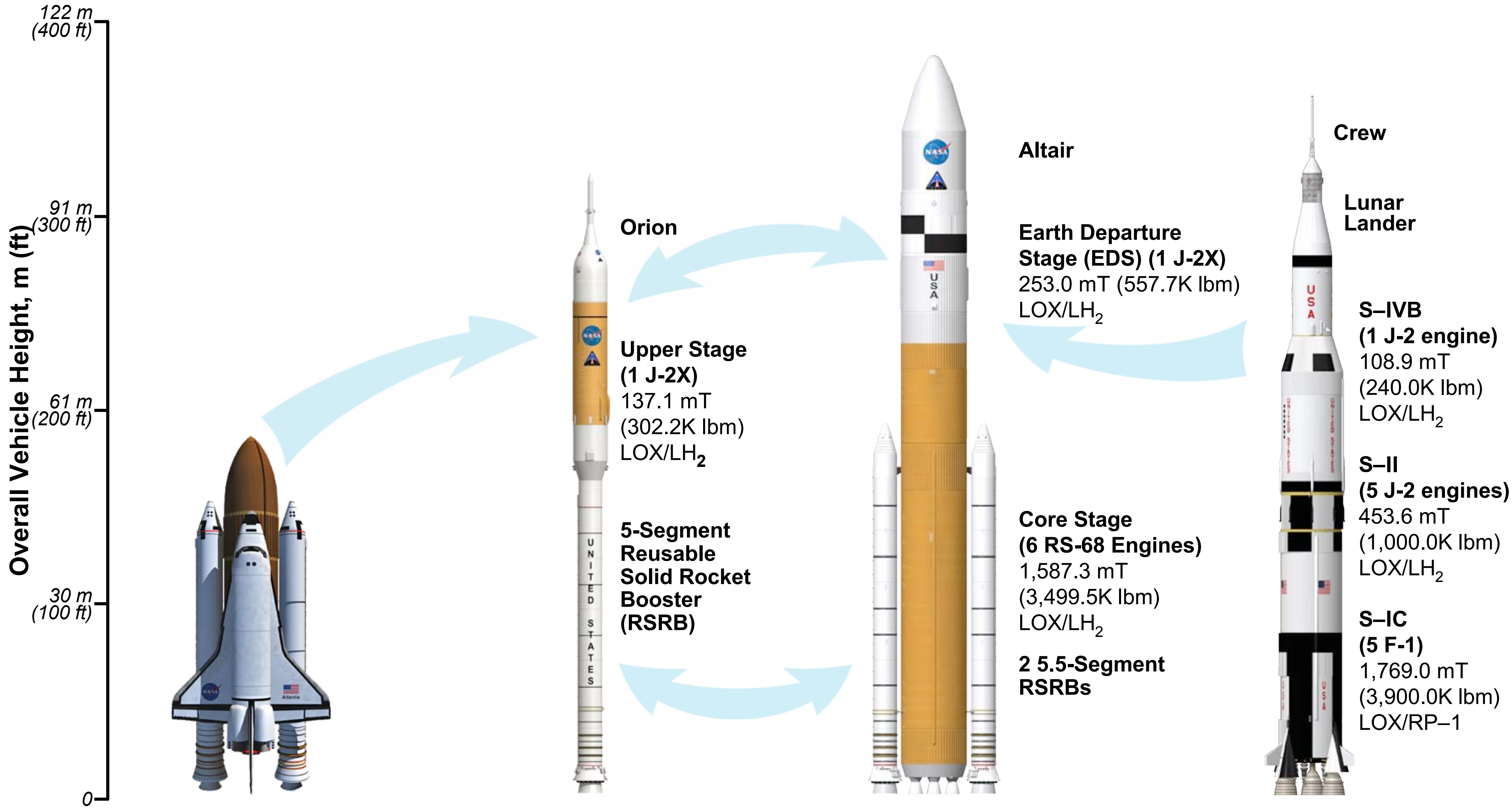
Building on a Foundation of Proven Technologies

Launch Vehicle Comparisons



Space Shuttle

Height: 56.1 m (184.2 ft)
Gross Liftoff Mass:
2,041.1 mT (4,500.0K lbm)
Payload Capability:
25.0 mT (55.1K lbm)
to Low Earth Orbit (LEO)

Ares I

Height: 99.1 m (325.0 ft)
Gross Liftoff Mass :
927.1 mT (2,044.0K lbm)
Payload Capability:
25.5 mT (56.2K lbm)
to LEO

Ares V

Height: 116.2 m (381.1 ft)
Gross Liftoff Mass :
3,704.5 mT (8,167.1K lbm)
Payload Capability:
71.1 mT (156.7K lbm) to TLI (with Ares I)
62.8 mT (138.5K lbm) to TLI
~187.7 mT (413.8K lbm) to LEO

Saturn V

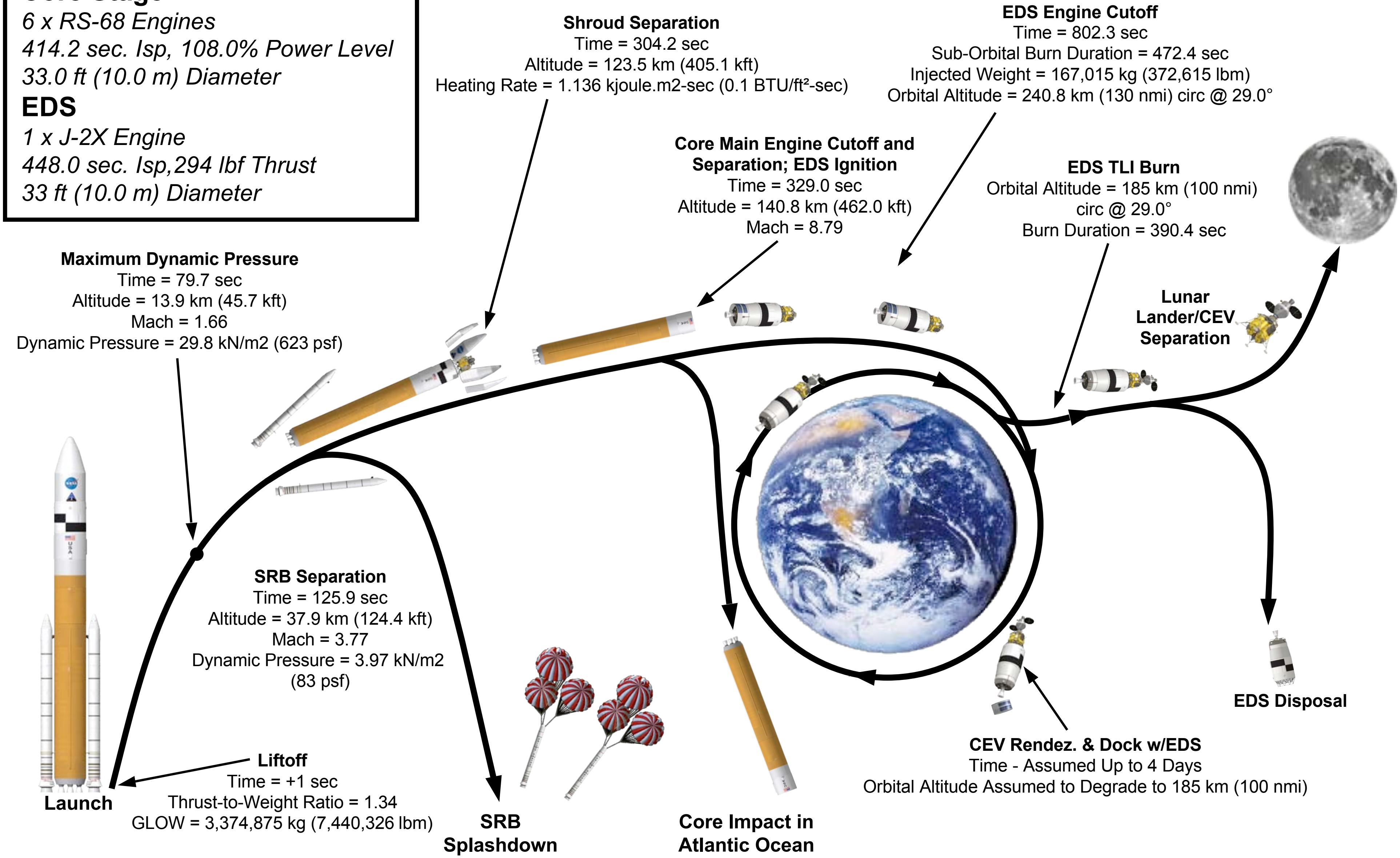
Height: 110.9 m (364.0 ft)
Gross Liftoff Mass :
2,948.4 mT (6,500K lbm)
Payload Capability:
44.9 mT (99.0K lbm) to TLI
118.8 mT (262.0K lbm) to LEO

DAC 2 TR6
LV 51.00.48

Ares V Ascent Profile for 1.5 Launch DRM

Vehicle 51.00.48

Core Stage
6 x RS-68 Engines
414.2 sec. Isp, 108.0% Power Level
33.0 ft (10.0 m) Diameter
EDS
1 x J-2X Engine
448.0 sec. Isp,294 lbf Thrust
33 ft (10.0 m) Diameter

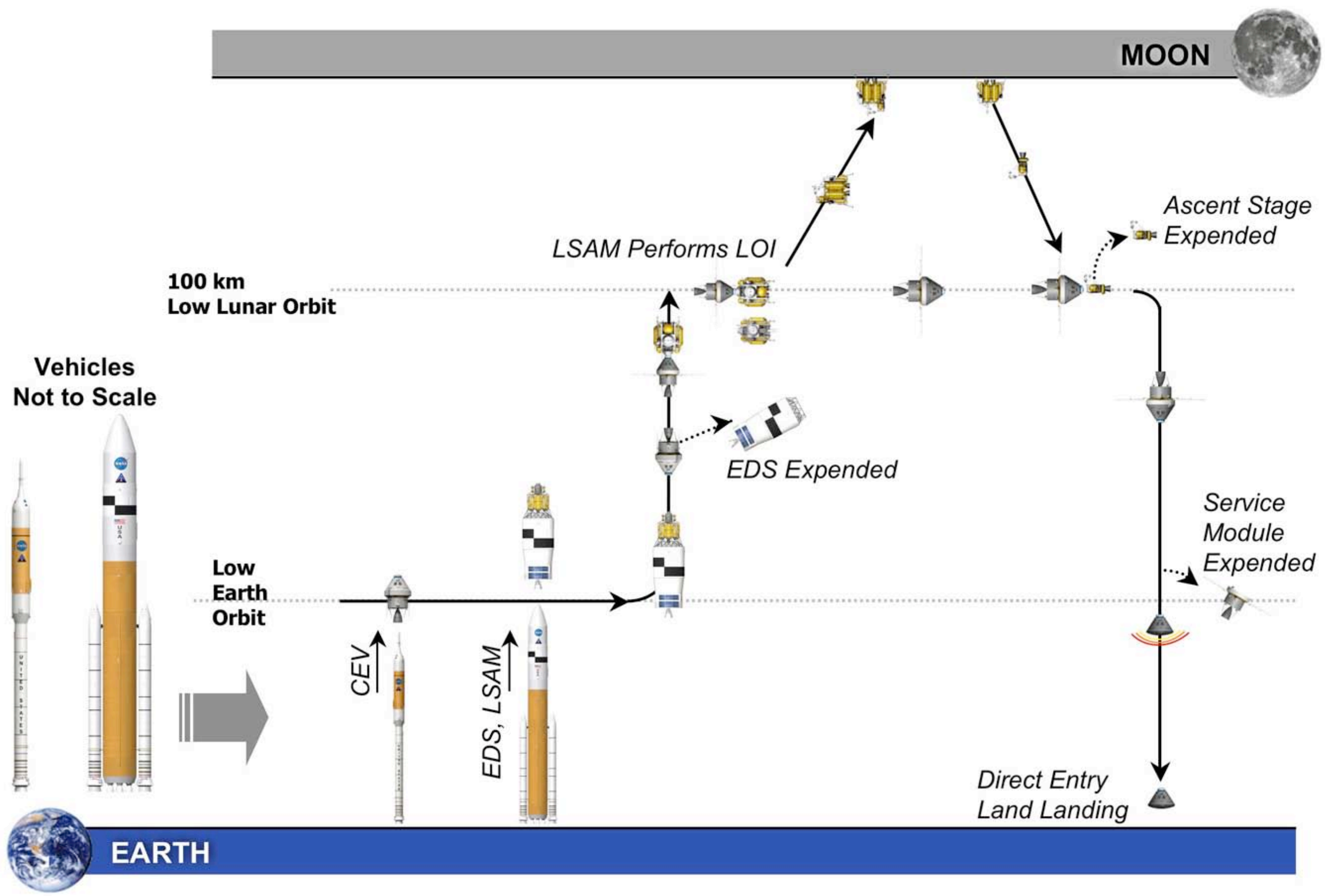


Constellation Lunar Sortie Mission

1.5 Launch Design Reference Mission (DRM)

♦ **Current Ares V concept analyses are based on 67 mT payload to TLI requirement (Lunar Lander + Crew Exploration Vehicle)**

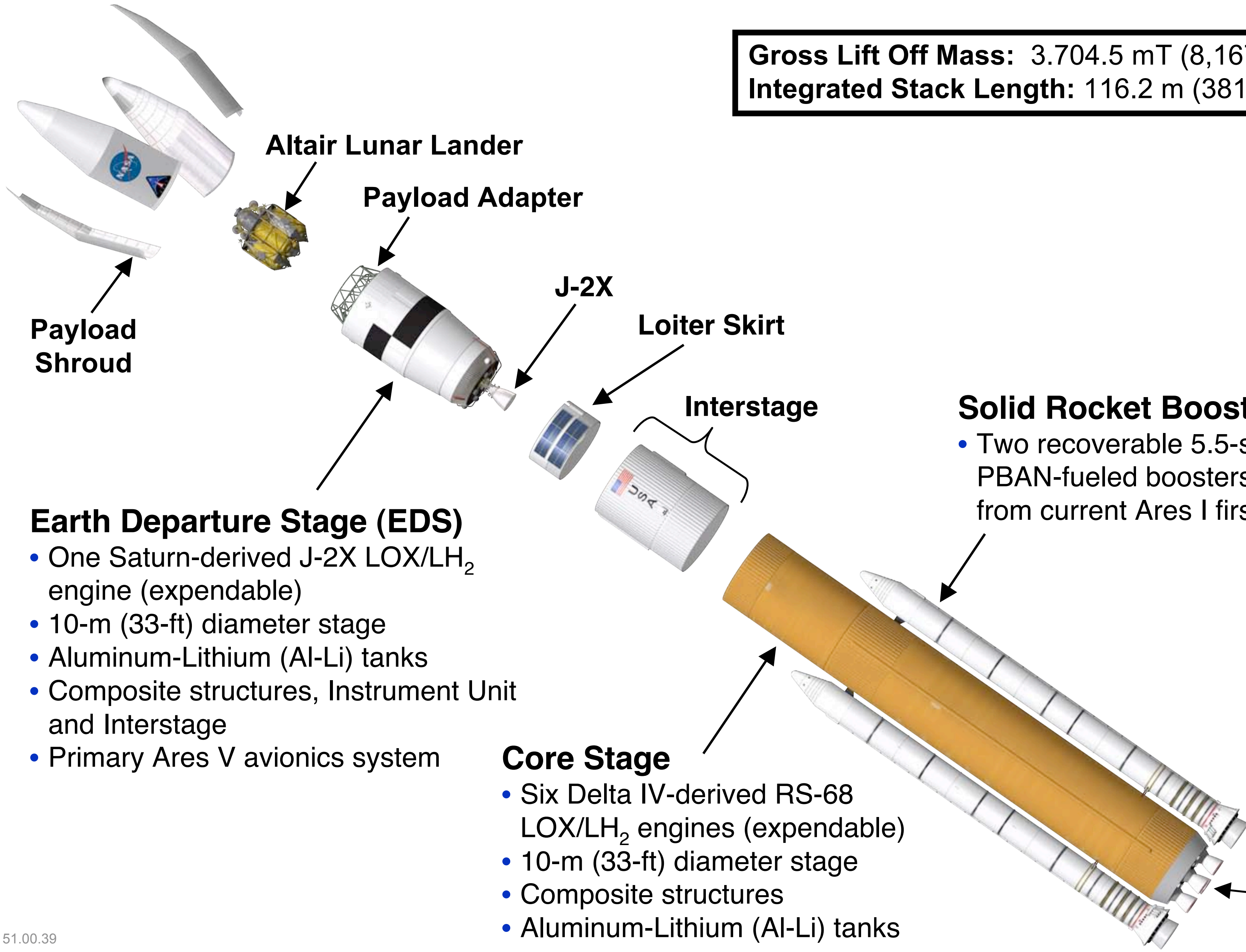
- Orbital Insertion at 130 nmi and 29.0° inclination
- Orbital decay during maximum 4-day loiter period
- Trans Lunar Injection (TLI) burn of 3175 m/s from 100 nmi



Ares V Elements

New POD Vehicle (51.00.48)

Gross Lift Off Mass: 3.704.5 mT (8,167.1K lbm)
Integrated Stack Length: 116.2 m (381.1 ft)



Earth Departure Stage (EDS)

- One Saturn-derived J-2X LOX/LH_2 engine (expendable)
- 10-m (33-ft) diameter stage
- Aluminum-Lithium (Al-Li) tanks
- Composite structures, Instrument Unit and Interstage
- Primary Ares V avionics system

Core Stage

- Six Delta IV-derived RS-68 LOX/LH_2 engines (expendable)
- 10-m (33-ft) diameter stage
- Composite structures
- Aluminum-Lithium (Al-Li) tanks

Solid Rocket Boosters (2)

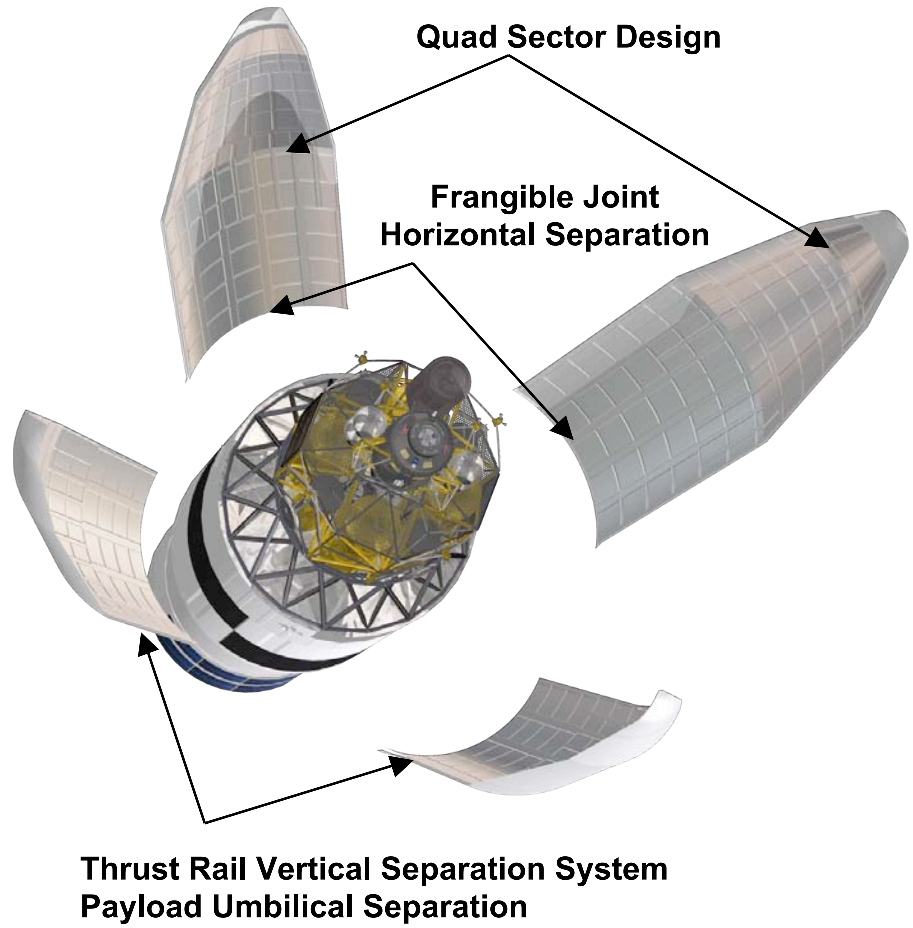
- Two recoverable 5.5-segment PBAN-fueled boosters (derived from current Ares I first stage)

Payload Shroud Current Design Concept

Mass: 9.1 mT (20.0k lbm)
POD Geometry: Biconic
Design: Quad Sector
Barrel Diameter: 10 m (33 ft)
Barrel Length: 9.7 m (32 ft)
Total Length: 22 m (72 ft)

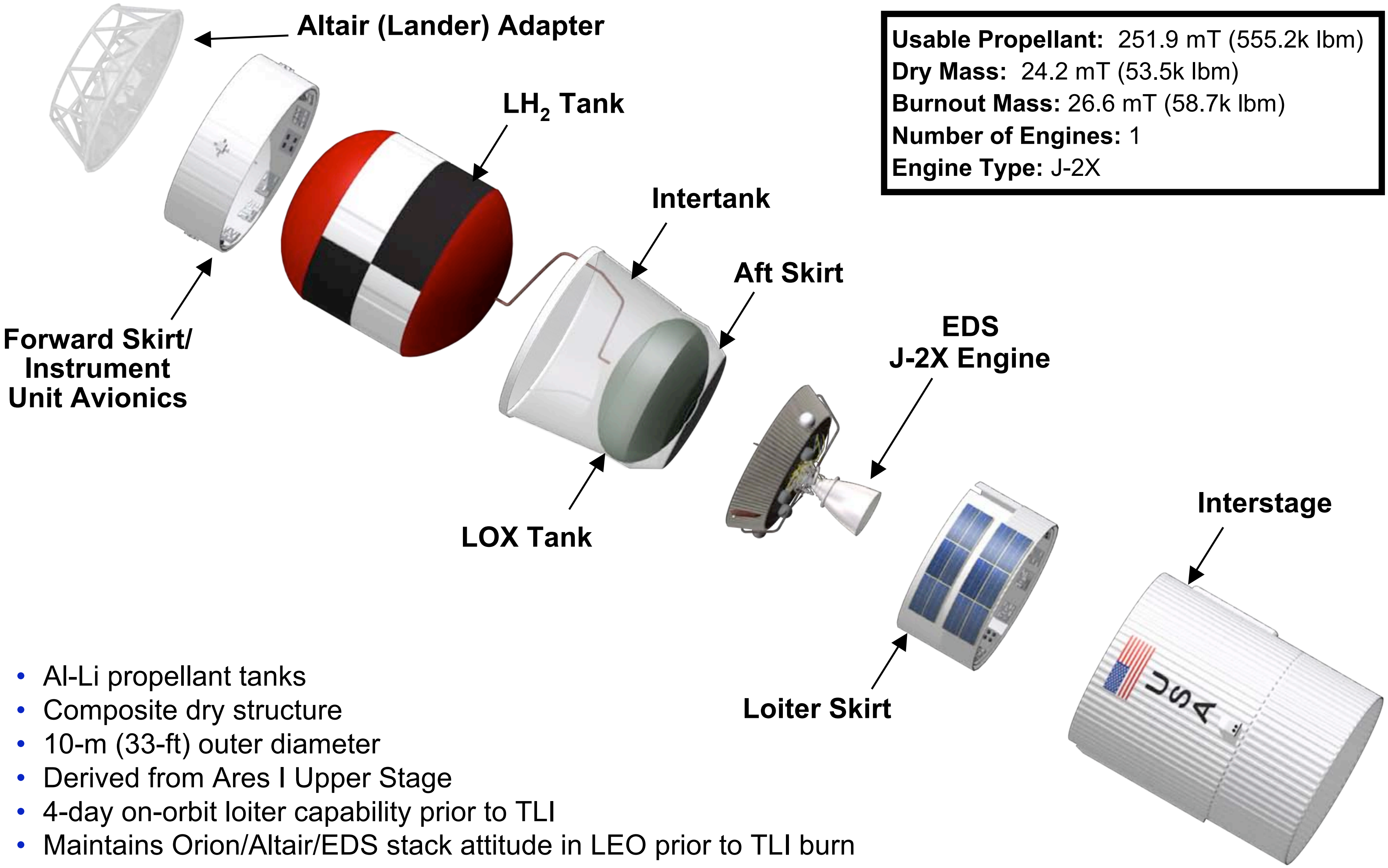
POD Shroud (Biconic) | **Leading Candidate (Ogive)**

- More internal volume with tangent ogive shroud
- Composite sandwich construction (carbon-epoxy face sheets, aluminum honeycomb core)
- Painted cork Thermal Protection System (TPS) bonded to outer face sheet with RTV
- Payload access ports for maintenance, payload consumables and environmental control (while on ground)



EDS Current Design Concept

Expanded View

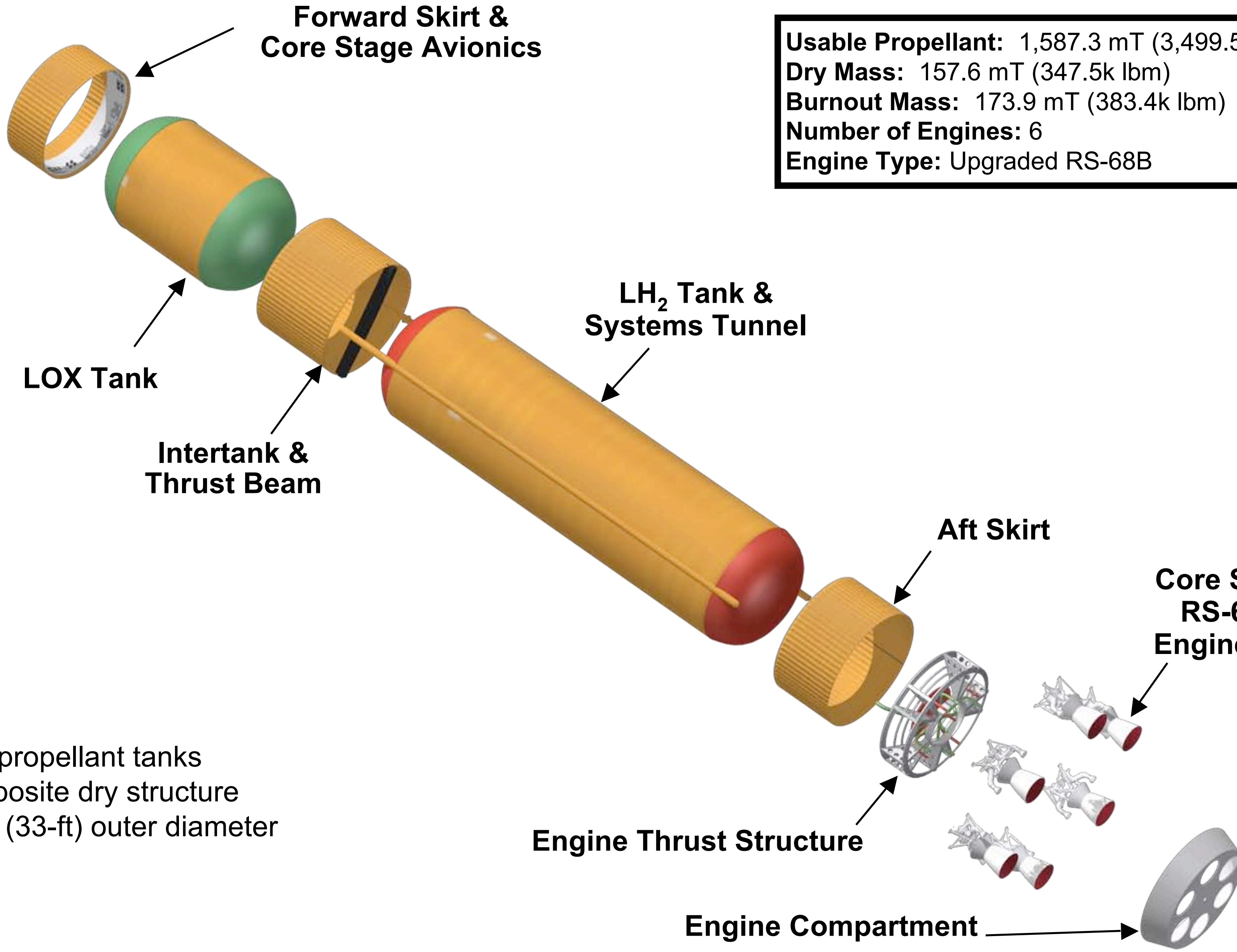


Usable Propellant: 251.9 mT (555.2k lbm)
Dry Mass: 24.2 mT (53.5k lbm)
Burnout Mass: 26.6 mT (58.7k lbm)
Number of Engines: 1
Engine Type: J-2X

- Al-Li propellant tanks
- Composite dry structure
- 10-m (33-ft) outer diameter
- Derived from Ares I Upper Stage
- 4-day on-orbit loiter capability prior to TLI
- Maintains Orion/Altair/EDS stack attitude in LEO prior to TLI burn
- EDS provides 1.5 kW of power to Altair from launch to TLI

Core Stage Current Design Concept

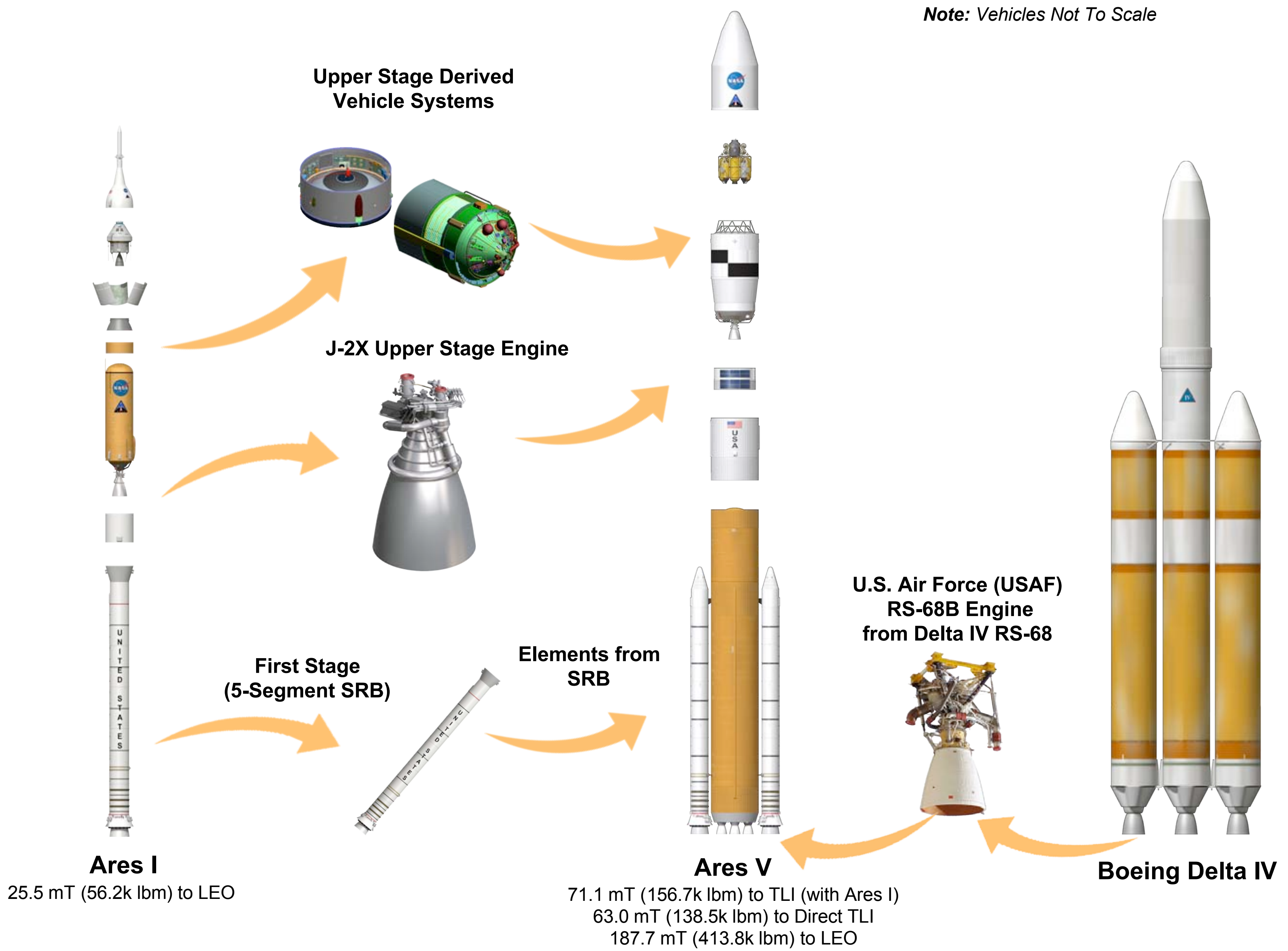
Expanded View



Usable Propellant:	1,587.3 mT (3,499.5k lbm)
Dry Mass:	157.6 mT (347.5k lbm)
Burnout Mass:	173.9 mT (383.4k lbm)
Number of Engines:	6
Engine Type:	Upgraded RS-68B

- Al-Li propellant tanks
- Composite dry structure
- 10-m (33-ft) outer diameter

Ares V Element Heritage



EDS J-2X Engine

Turbomachinery
• Based on J-2S MK-29 design

Flexible Inlet Ducts
• Based on J-2 and J-2S ducts

Gas Generator
• Based on RS-68 design

Open-Loop Pneumatic Control
• Similar to J-2

Engine Controller
• Based directly on RS-68 design and software architecture

HIP-bonded Main Combustion Chamber (MCC)
• Based on RS-68 demonstrated technology

Regeneratively Cooled Nozzle Section
• Based on long history of RS-27 success

Nozzle Extension

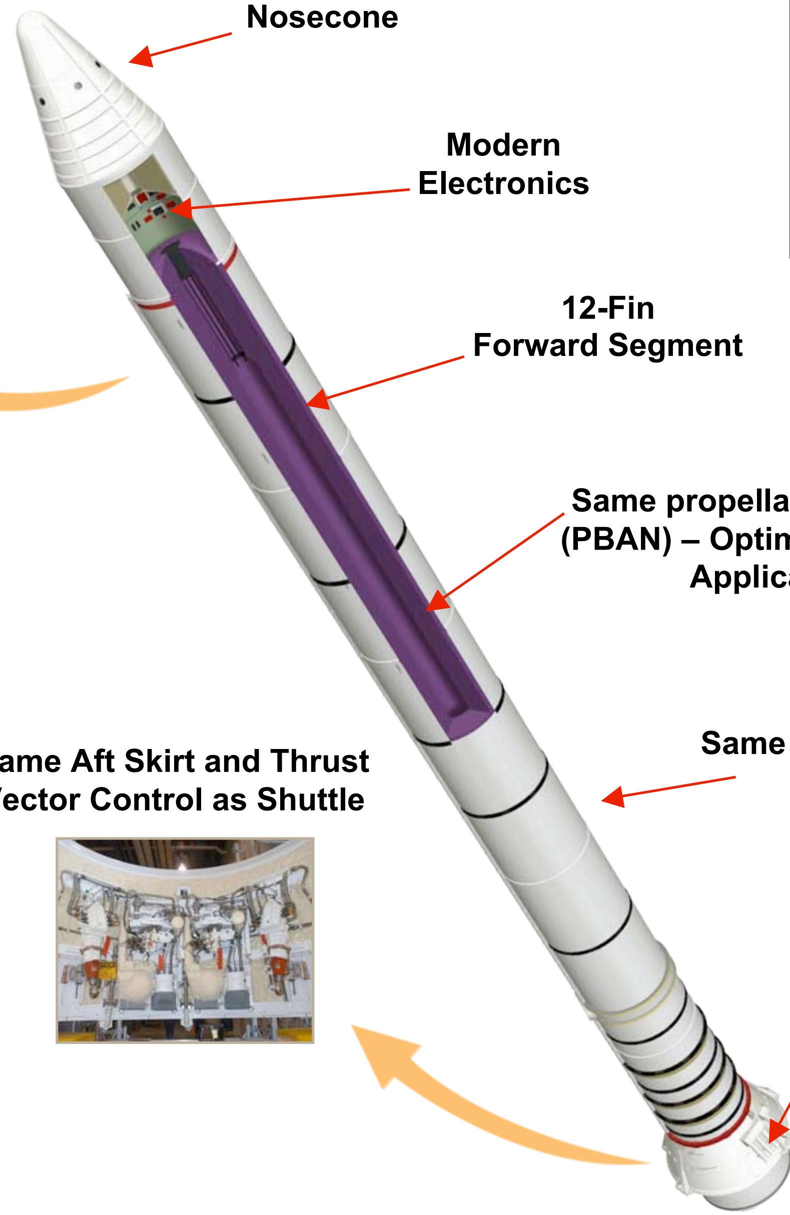
Mass: 2.5 mT (5,450 lbm)
Thrust: 1,300 kN (294k lbf) @ vac (100%)
Isp: 448 sec @ vac (100%)
Height: 4.7 m (185 in)
Diameter: 3.0 m (120 in)

Essentially identical to Ares I
- **Earth-orbit loiter**
- **On-orbit restart**

Ares V SRB

Ares V SRB is similar to Space Shuttle and Ares I, but optimized for lunar missions


New 150-ft diameter parachutes



Same Aft Skirt and Thrust Vector Control as Shuttle

Each Booster:

Mass: 791.5 mT (1,744.9k lbm)

Thrust: 16.86 MN (3.79M lbf)

Burn Duration: 126 sec

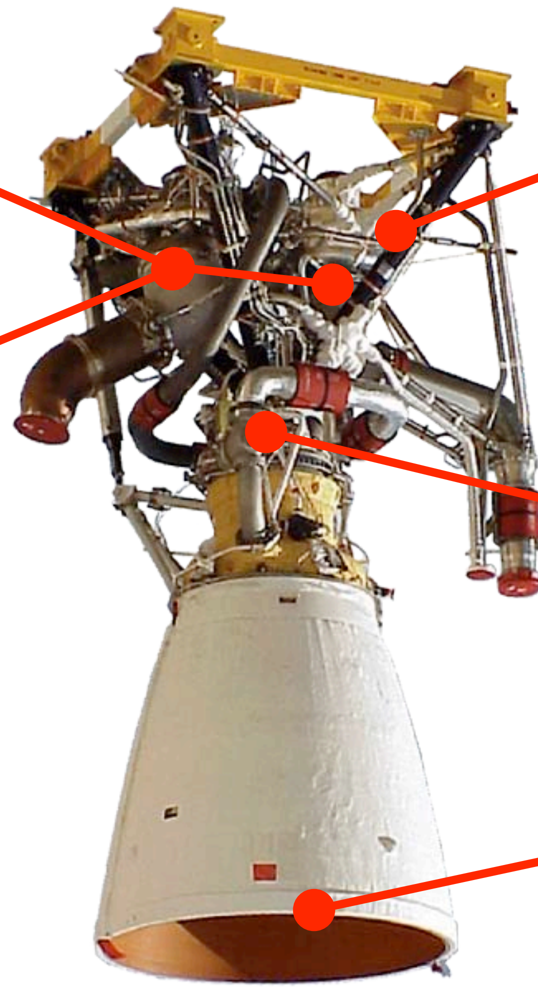
Height: 59 m (193 ft)

Diameter: 3.7 m (12 ft)

Core Stage Upgraded USAF RS-68 Engine

⁎ Redesigned turbine nozzles to increase maximum power level by ≈ 2%

Redesigned turbine seals to significantly reduce helium usage for pre-launch



Helium spin-start duct redesign, along with start sequence modifications, to help minimize pre-ignition free hydrogen

⁎ Higher element density main injector improving specific impulse by ≈ 2% and thrust by ≈ 4%

Increased duration capability ablative nozzle

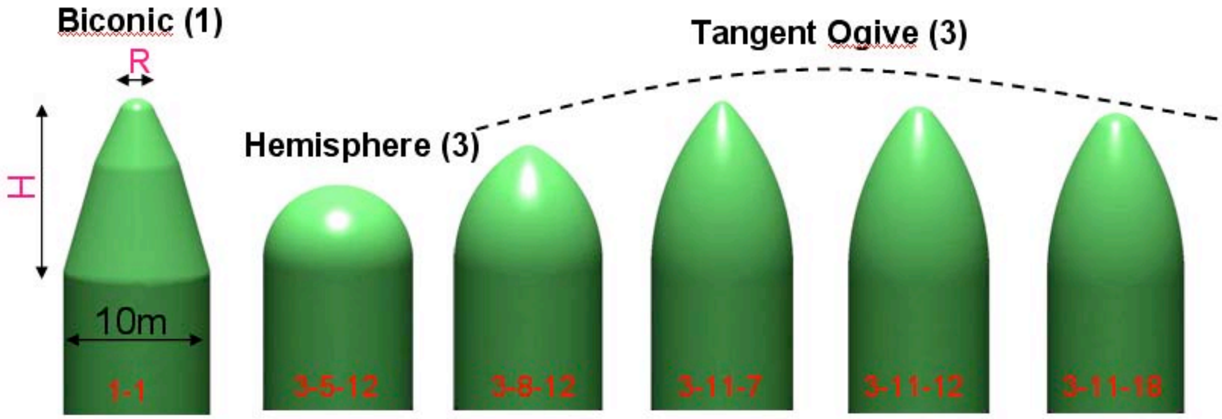
Other RS-68A upgrades or changes that may be included:

- Bearing material change
- New Gas Generator igniter design
- Improved Oxidizer Turbo Pump temp sensor
- Improved hot gas sensor
- Second stage Fuel Turbo Pump blisk crack mitigation
- Cavitation suppression
- ECU parts upgrade

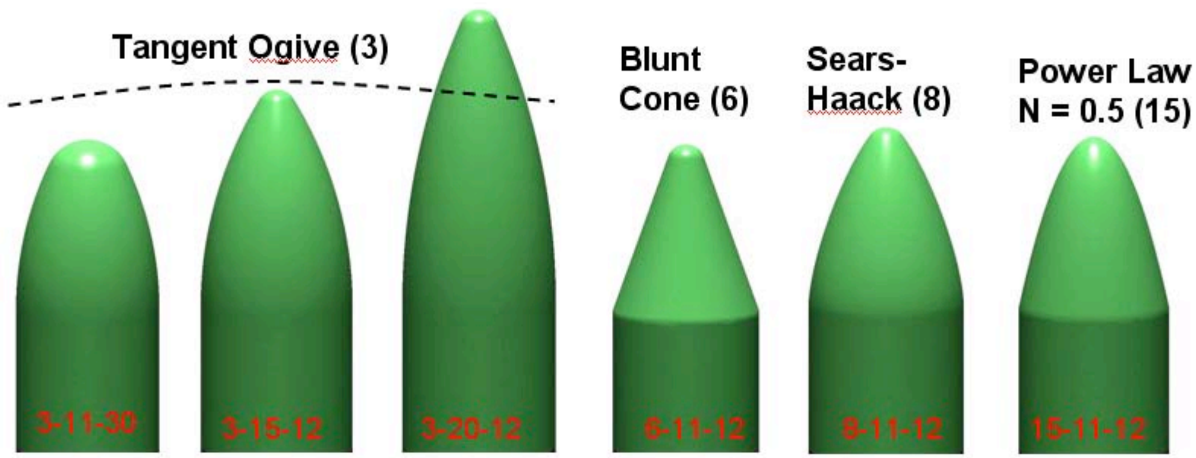
⁎ **RS-68A Upgrades**

Shroud Shape Trade Study

Initial Trade Space



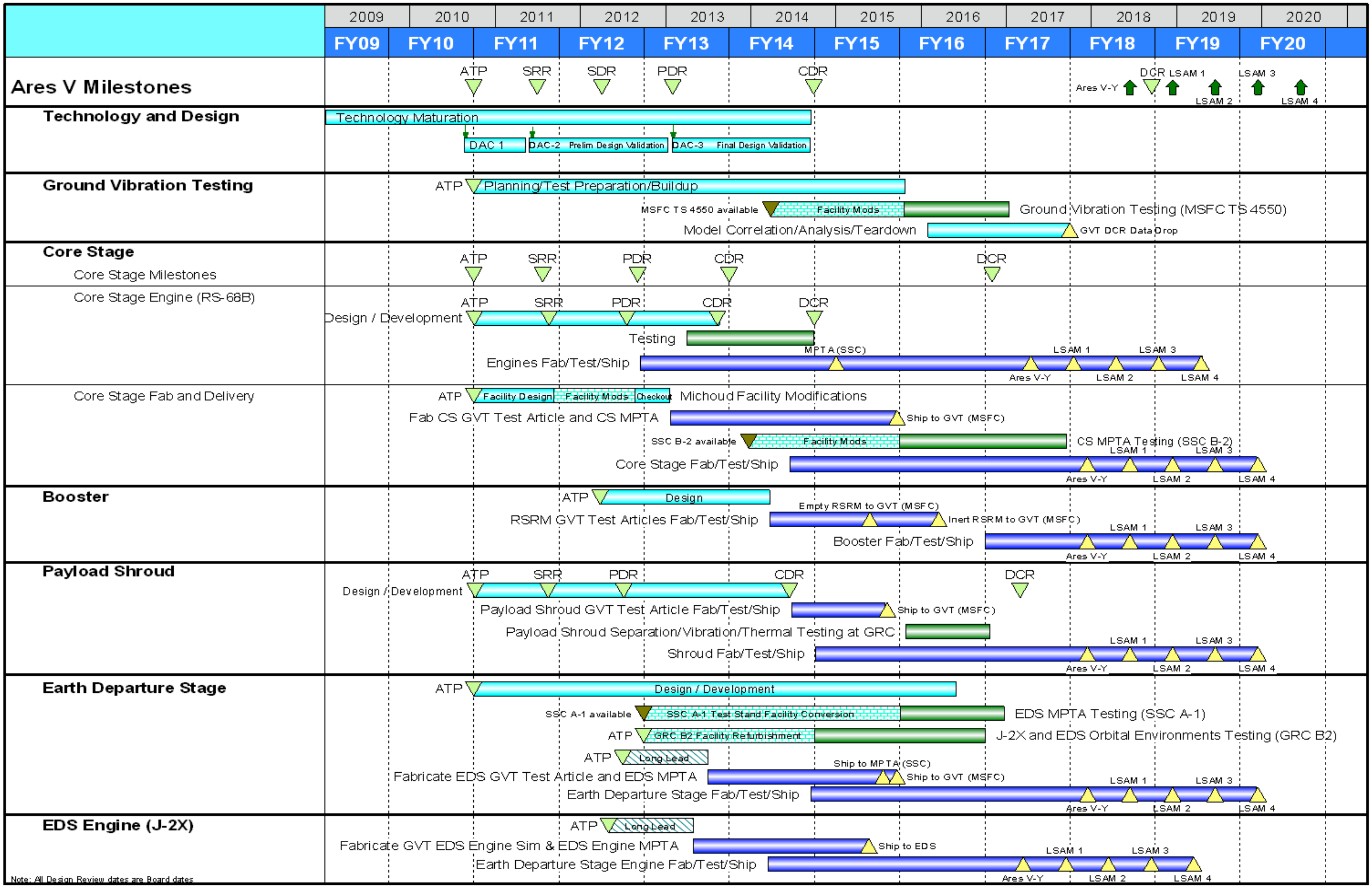
H (mm) :	11,923	5,000	8,000	11,923	11,923	11,923
R (mm) :	1,280	1,280	1,280	750	1,280	1,800



H (mm) :	11,923	15,000	20,000	11,923	11,923	11,923
R (mm) :	3,000	1,280	1,280	1,280	1,280	1,280

All shroud options have 9.7m barrel height to accommodate current Lunar Lander configuration.

Ares V Summary Schedule



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Ares V Performance Description

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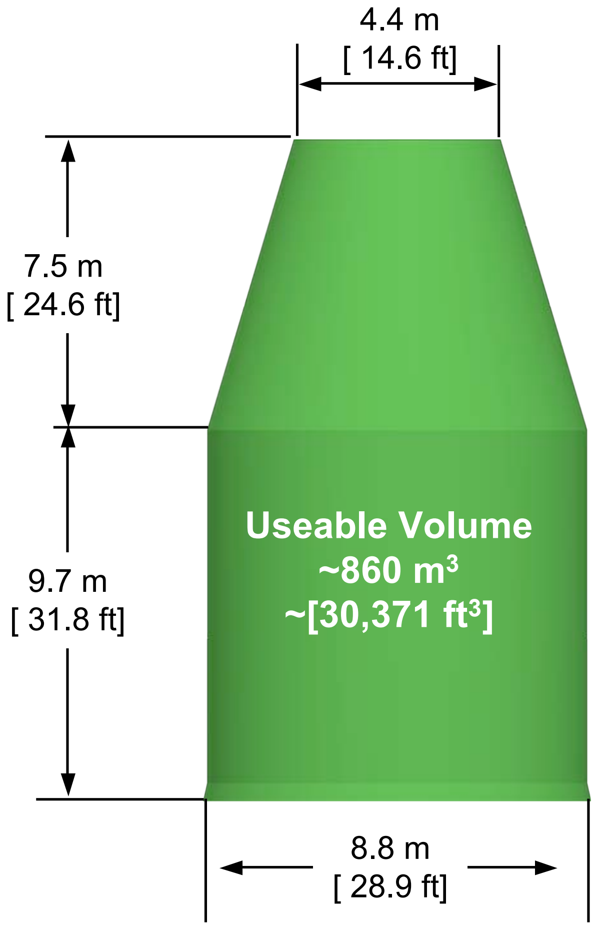
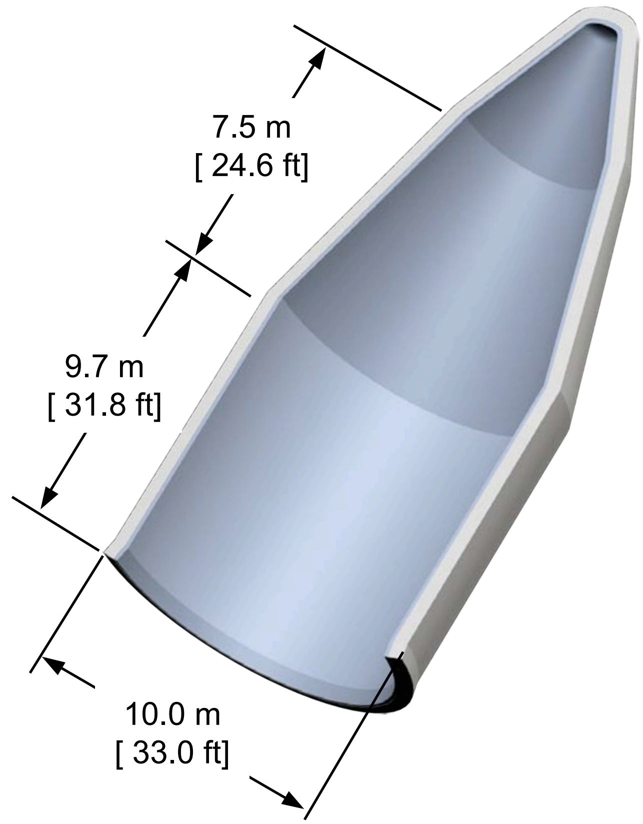
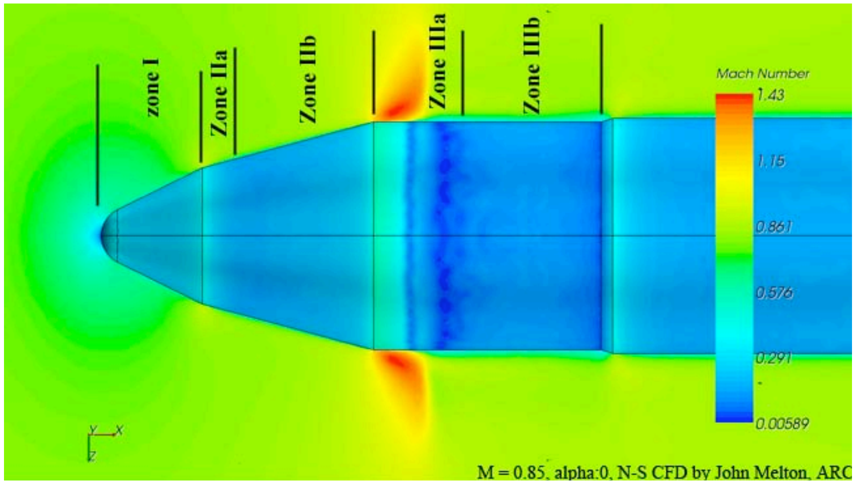
Current Ares V Shroud Concept





Preliminary Aero-acoustic Analysis

Transonic and Max-Q Acoustics



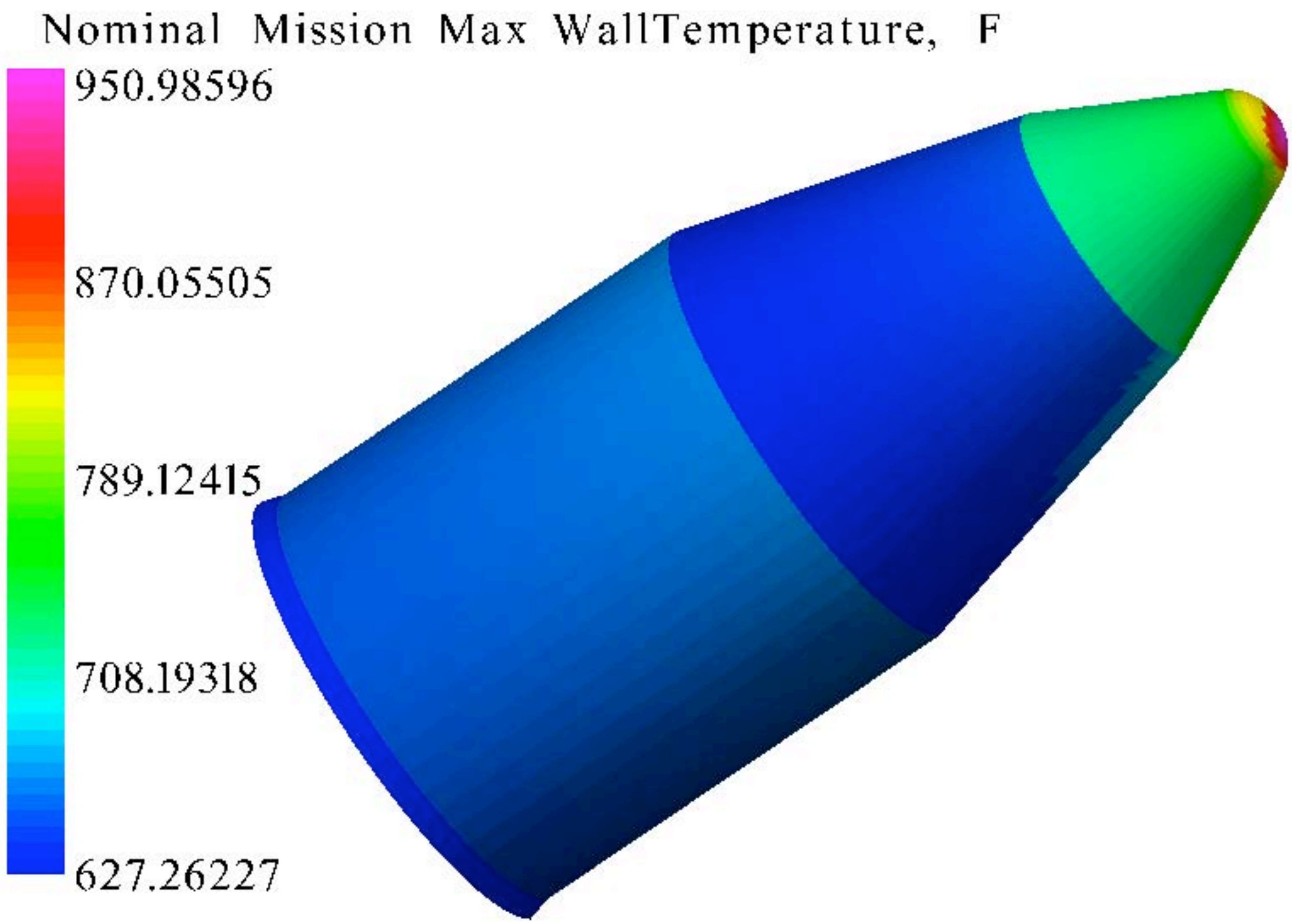
- Predicted ascent max-acoustic levels
- Conceptual design based on acoustic blanket thicknesses used on Cassini mission

Table I. Estimated max Overall Fluctuating Pressure Level (OAFPL) on Shroud external regions

Zone	I	IIa	IIb	IIIa	IIIb
Criteria for Max OAFPL	Attached Turbulent Boundary Layer	Weak Transonic Shock	Attached Turbulent Boundary Layer	Strong Transonic Shock & Separation	Weak Transonic Shock
Expected Mach # for max OAFPL	1.65	0.93	1.65	0.85	0.85
Q (psf)	707	520	707	475	475
Crms	0.007	0.07	0.007	0.12	0.035
OAFPL (dB)	142	159	142	163	152

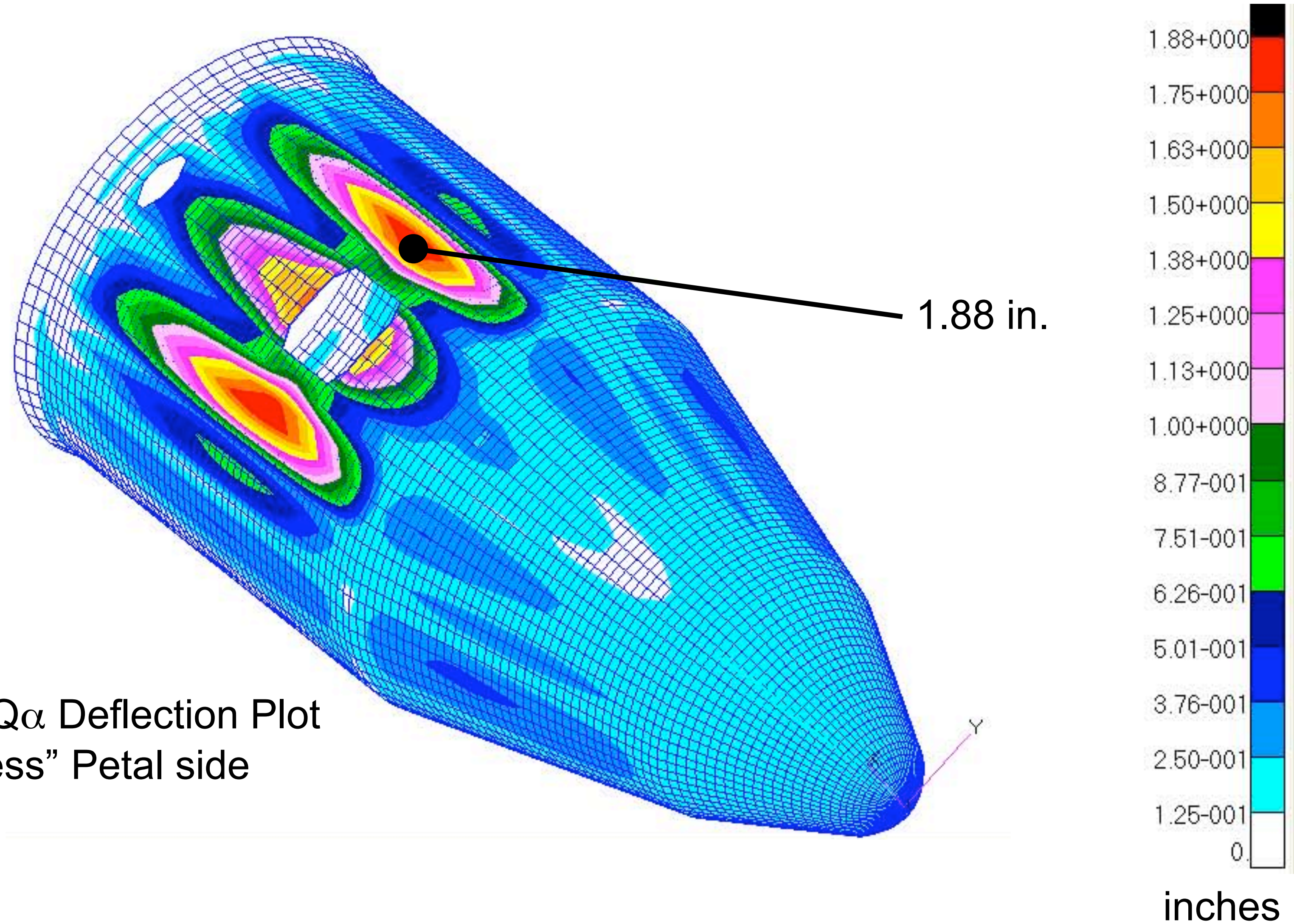
Preliminary Aerothermal Analysis

Mission Maximum Temperature



Preliminary Structural Analysis

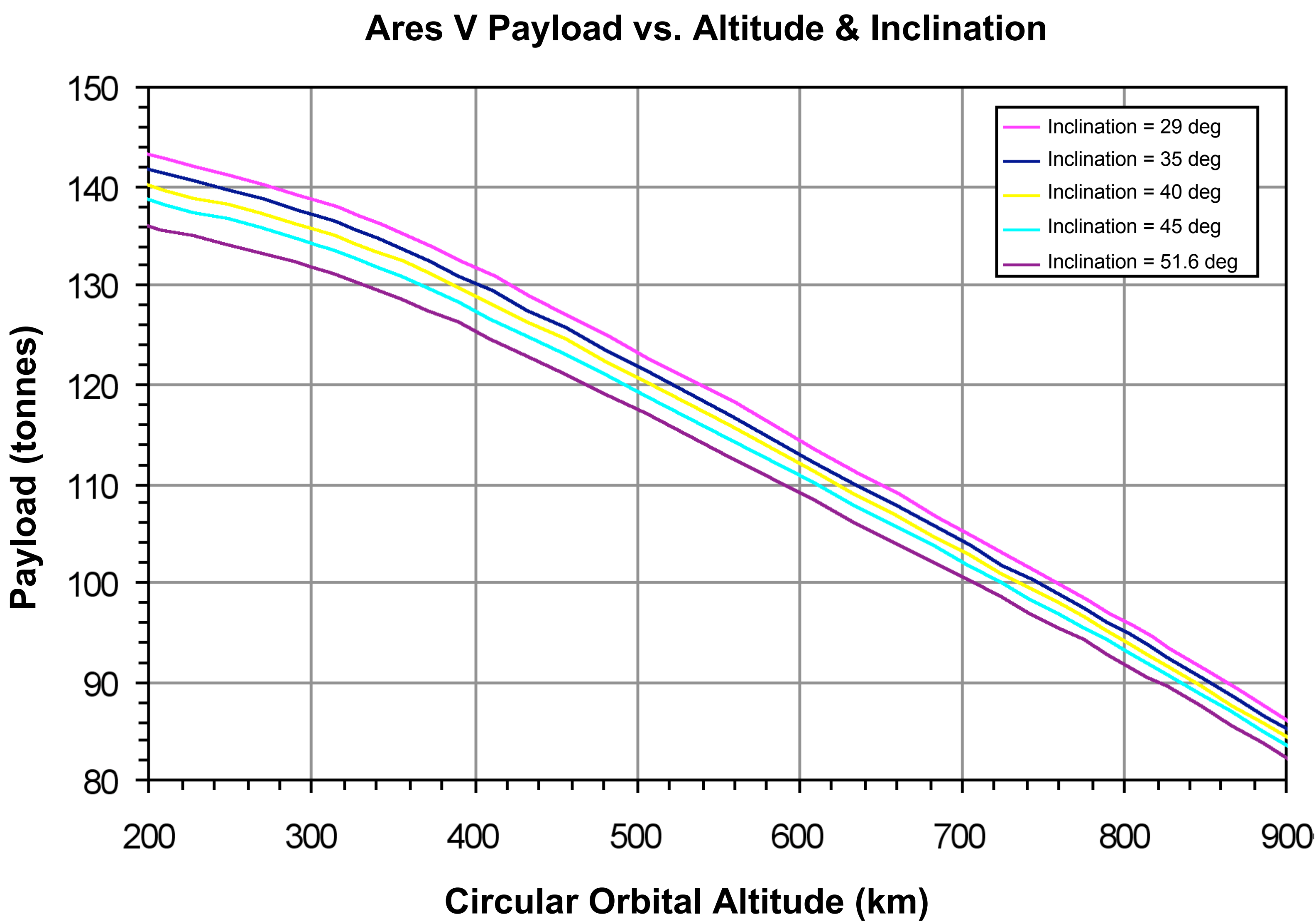
Maximum Static Deflection



Max Qα Deflection Plot
"Access" Petal side

Ares V (51.00.39) LEO Performance

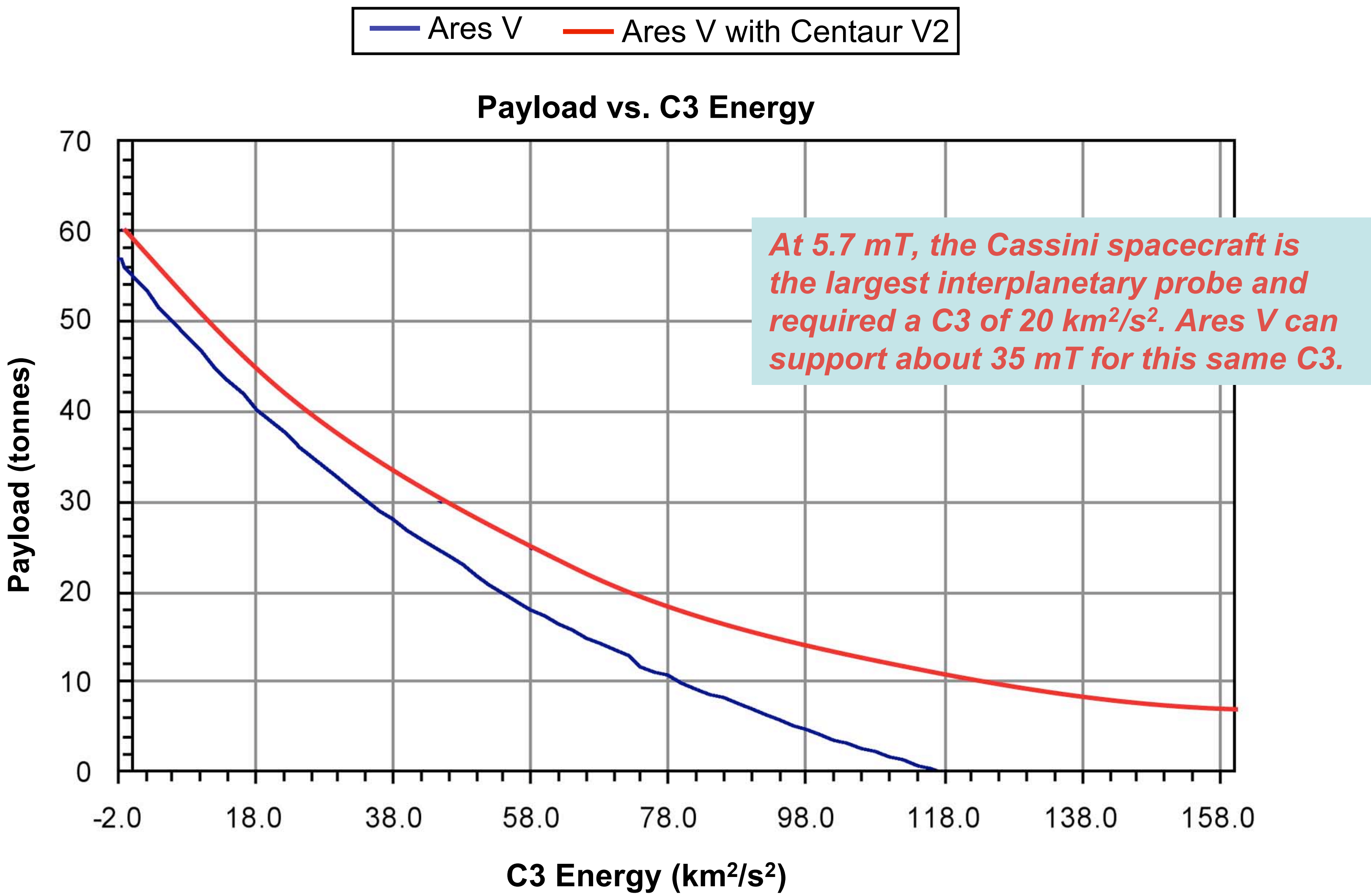
Previous POD Shroud



LEO performance for new Constellation point of departure vehicle (51.00.48) is expected to exceed values shown here. Performance analysis will be updated for the 51.00.48 vehicle.

Ares V (51.00.39) Escape Performance

Previous POD Shroud



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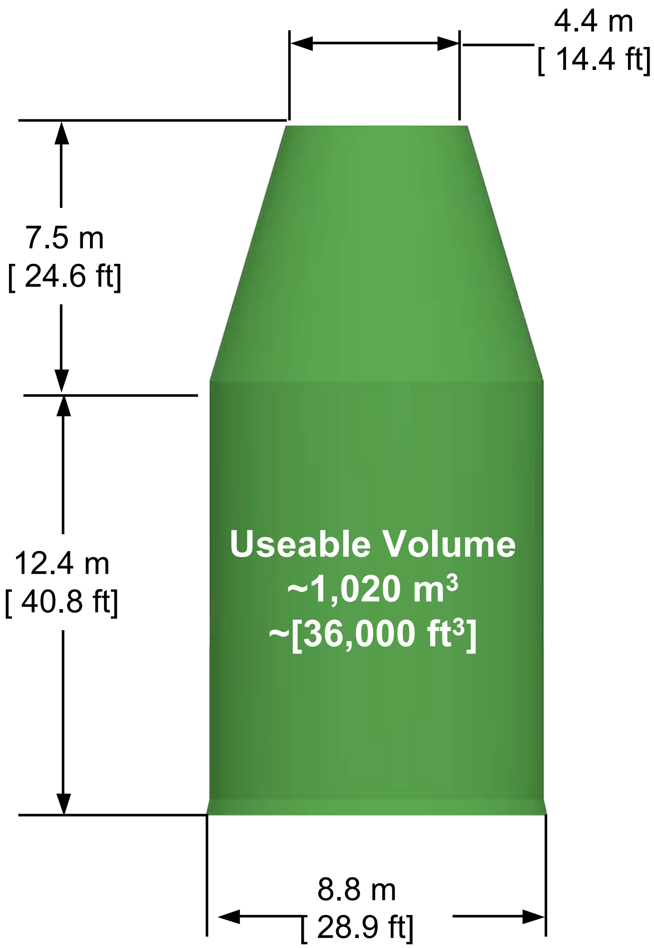
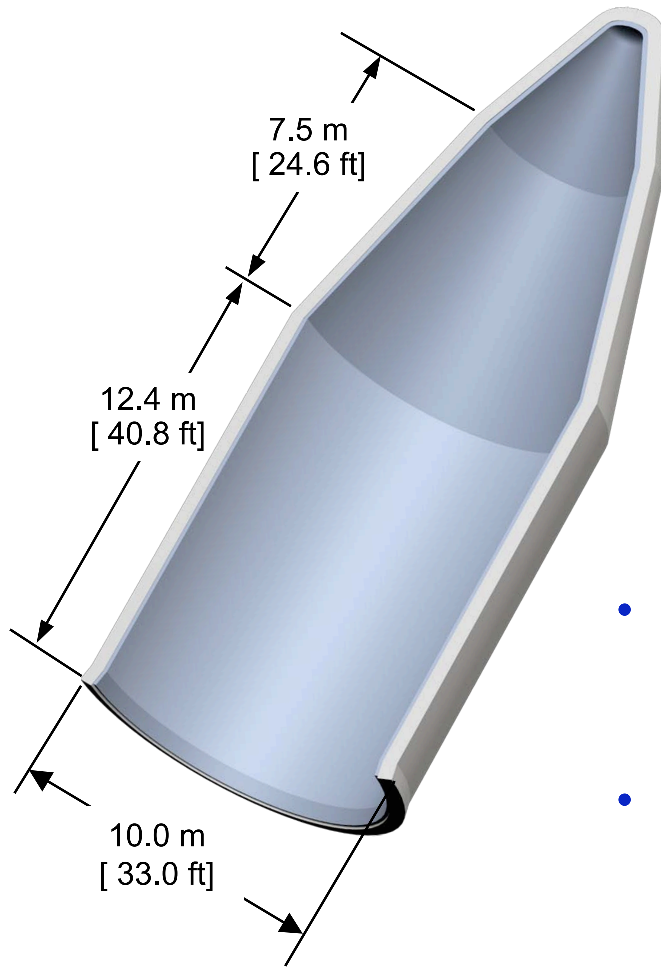
Notional Ares V Shroud for Other Missions

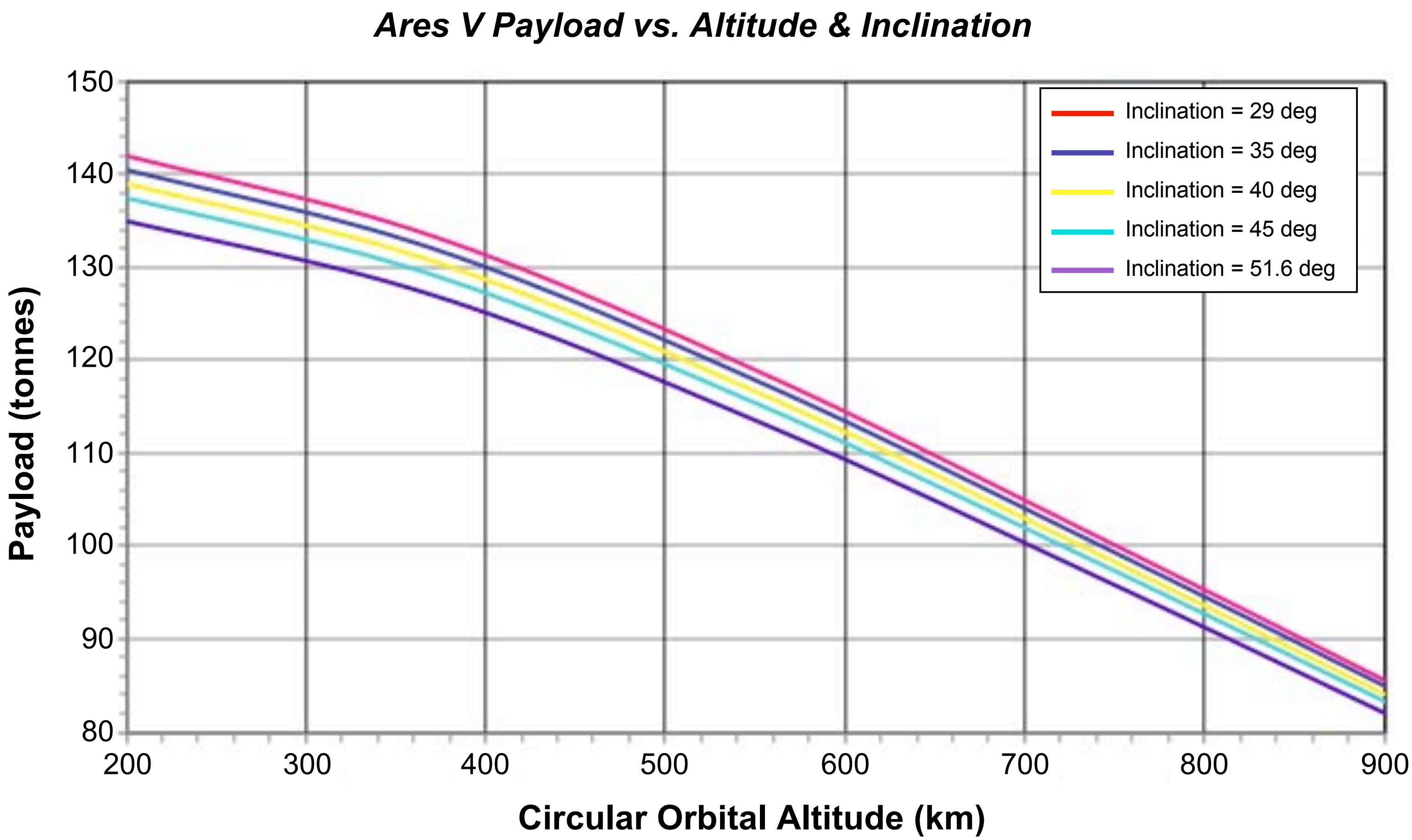




- Maximum Barrel Length Constrained Vehicle Assembly Building (VAB) Height
- Increased Barrel Length Introduces Theoretical Reduction of Payload Capability of 200 kg

Ares V LEO Performance

Extended Shroud



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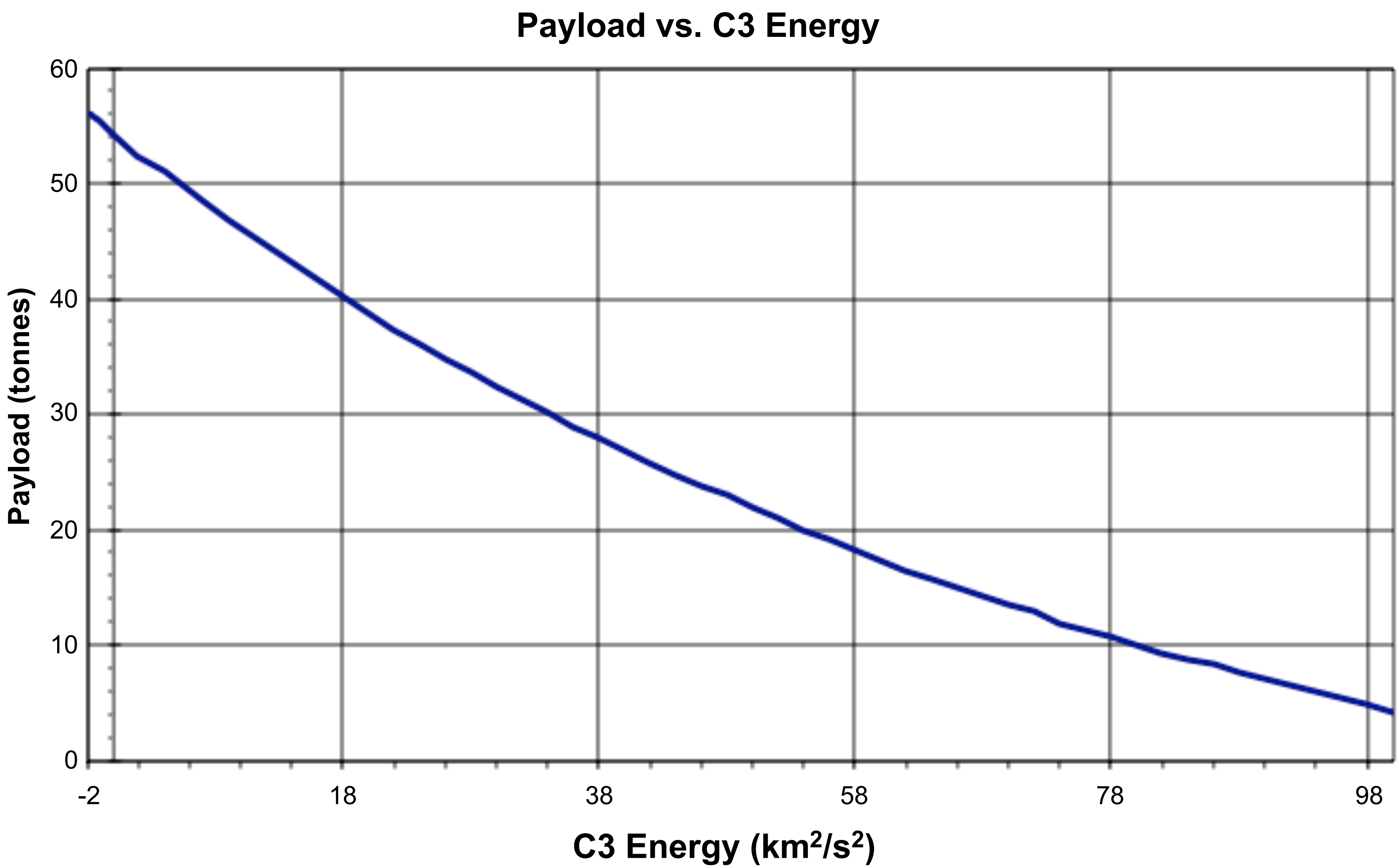
Ares V Escape Performance

Extended Shroud



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Ares V Performance for Selected Missions

Comparison of POD and Extended Shroud

1) **Sun-Earth L2 Mission**
   - Target C3 energy of -0.7 km^2/s^2 @ 29.0 degrees
2) **Geosynchronous Transfer Orbit (GTO)**
   - Final orbit: 185 km x 35,786 km @ 27 degrees
   - Intermediate orbit: LEO insertion at 185 km circ. @ 28.5 degrees
3) **Geosynchronous Earth Orbit (GEO)**
   - Final orbit: 35,786 km circular @ 0 degrees
   - Intermediate orbit: LEO insertion at 185 km circ. @ 28.5 degrees
     - Note: assessed as single burn; no boil-off assumed between burns; 500 lb_m knock-down included for additional engine restart
4) **Lunar Outpost Cargo (Direct TLI), Reference**
   - Target C3 energy of -1.8 km^2/s^2 @ 29.0 degrees

Mission Profile	Target	Constellation POD Shroud		Extended Shroud	
		Payload (lbm)	Payload (t)	Payload (lbm)	Payload (t)
1) Sun-Earth L2	C3 of -0.7 km^2/s^2	123,100	55.8	121,600	55.1
2) GTO Injection	Transfer DV 8,200 ft/s	155,100*	70.3*	153,700*	69.7*
3) GEO	Transfer DV 14,100 ft/s	79,700	36.2	78,700	35.7
4) Cargo Lunar Outpost (TLI Direct), Reference	C3 of -1.8 km^2/s^2	125,300	56.8	123,700	56.1

* Performance impacts from structural increases due to larger payloads has not been assessed

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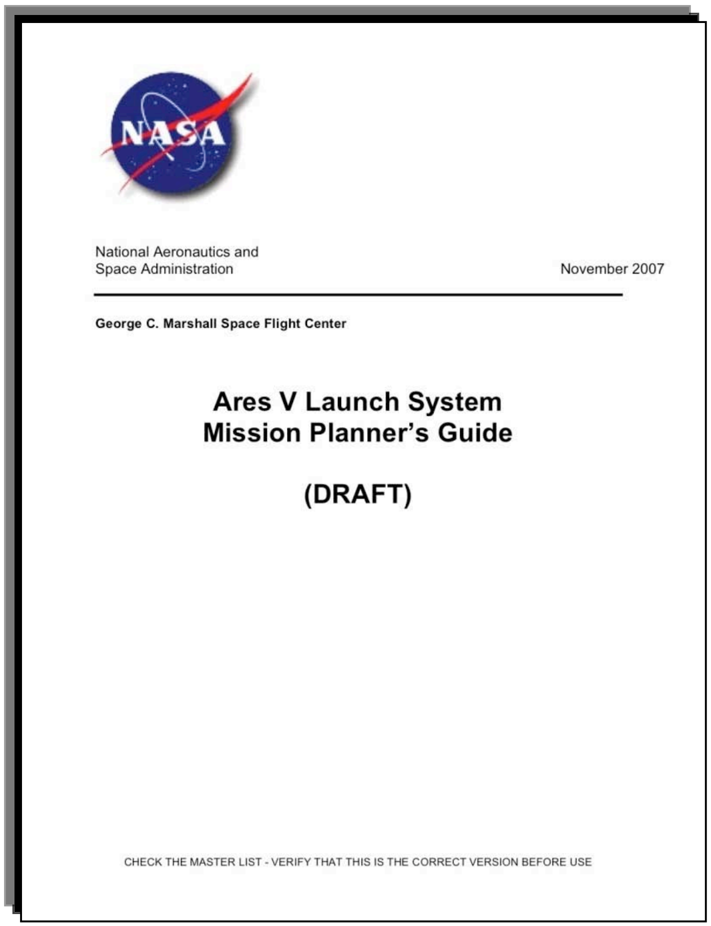
Developing Ares V Launch System Mission Planner's Guide


National Aeronautics and Space Administration

November 2007

George C. Marshall Space Flight Center

Ares V Launch System Mission Planner's Guide

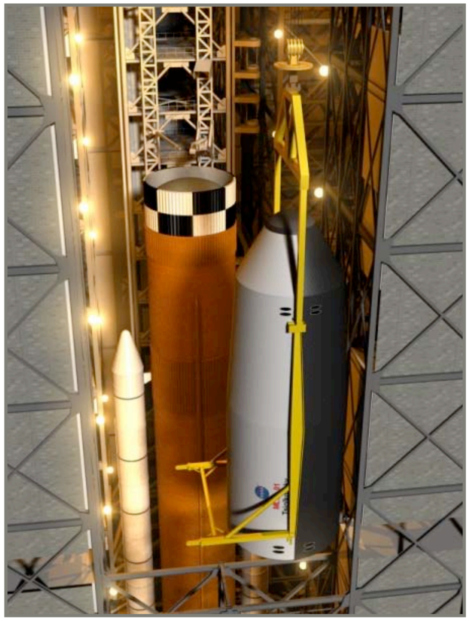
(DRAFT)

CHECK THE MASTER LIST - VERIFY THAT THIS IS THE CORRECT VERSION BEFORE USE

- **Mission Planner Guide Planned for Draft Release in Summer 2008**
  - Interface Definitions
    - Fairings, Adapters…
  - Mission Performance
  - Development Timelines
  - Concept of Operations
  - Potential Vehicle Evolution and Enhancements
  - Need Past Astronomy Mission Data
  - Based on 51.00.39 concept

Summary

- The focus of design efforts in the near future will be on the primary Lunar mission
- We are currently just beginning to integrate the design functions from the various centers for this mission
- We appreciate all thoughts and ideas for different ways to use the Ares V platform



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Backup

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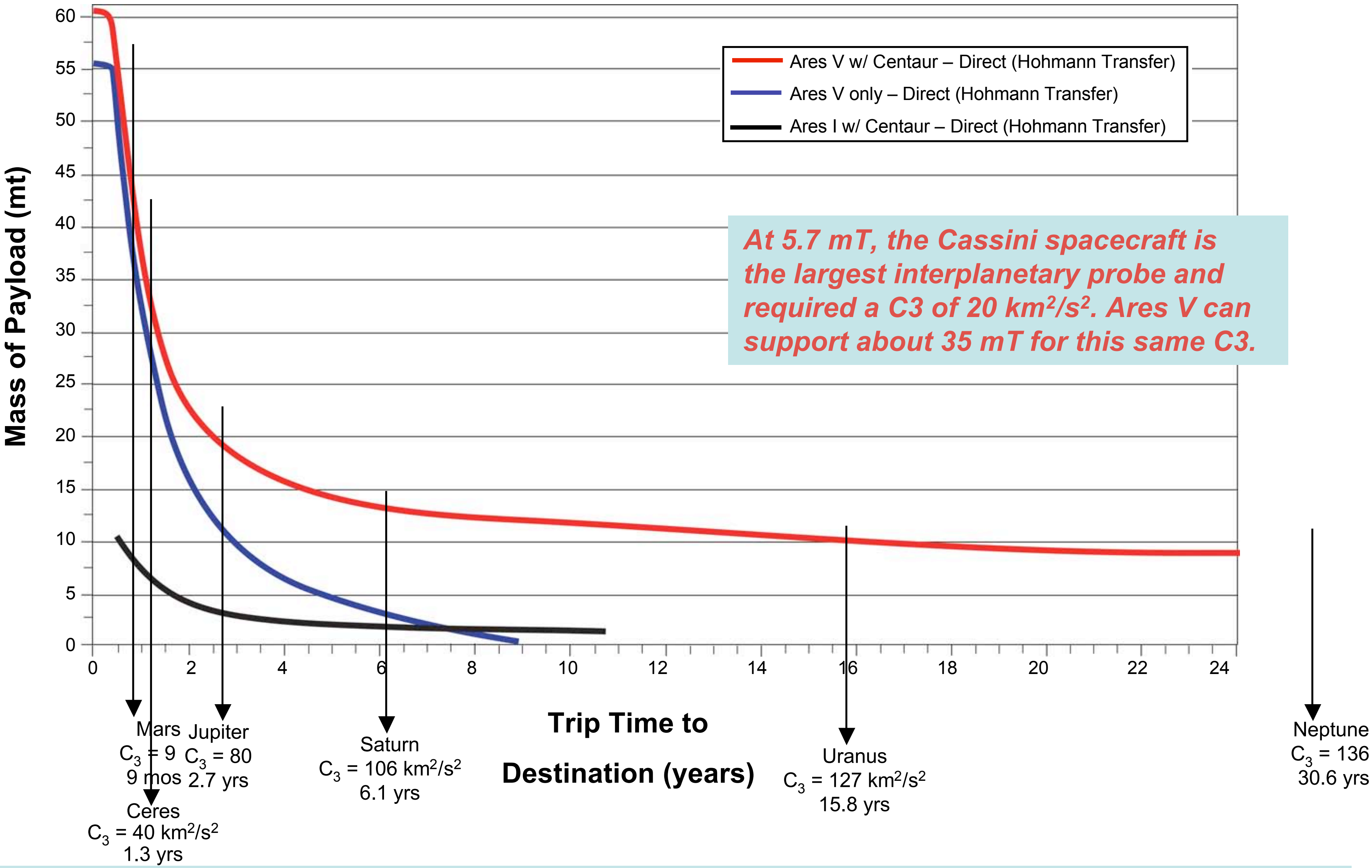
Payload vs. Trip Times for Representative Missions

Constellation POD Shroud



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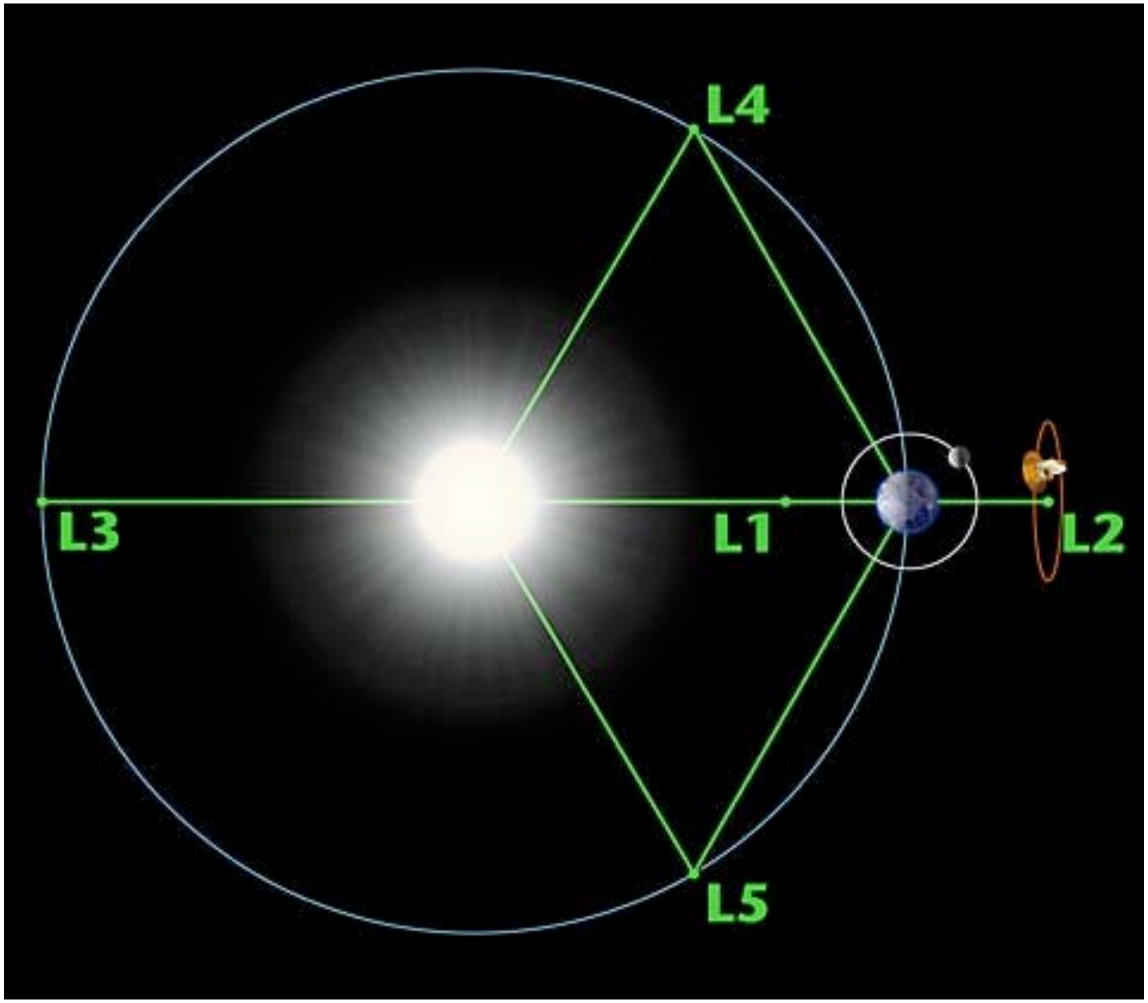
Ground Rules and Assumptions

- **All trajectories analyzed using POST3D** (Program to Optimize Simulated Trajectories - 3 Dimensional)
- **Flight performance reserve is based on the Ares V LEO mission, and is held constant for all cases**
- **No gravity assists**
- **Interplanetary trip times are based on Hohmann transfers** (limited to ~24 years max.)
- **Payload mass estimates are separated spacecraft mass, and include payload adapter and any mission peculiar hardware** (if required)
- **Ares V vehicle based on configuration 51.00.39, but w/ Upper Stage burnout mass from configuration 51.00.34** (propellant tanks not resized for high C_3 missions)
- **For cases incorporating a kick stage:**
  - Ares I and Ares V employ 2-engine Centaur from Atlas V
  - Additional adapter mass of 6,400 lb_m assumed
  - No adjustments to aerodynamic data
- **Propellant mass for:**
  - Ares V LEO missions: held constant at 310,000 lbm
  - Ares I and V C_3 missions and Ares I LEO missions: maximum propellant load
- **No Upper Stage propellant off-loading for Ares I and Ares V C_3 cases**
- **Transfer orbit to Sun-Earth L_2 point is a direct transfer w/ C_3 = -0.7 km²/s²**
  - Payload can be increased by using a lunar swingby maneuver
- **All cases targeting a C_3 are of longer duration than the J-2X constraint of 500 seconds**

Sun-Earth Lagrange Points

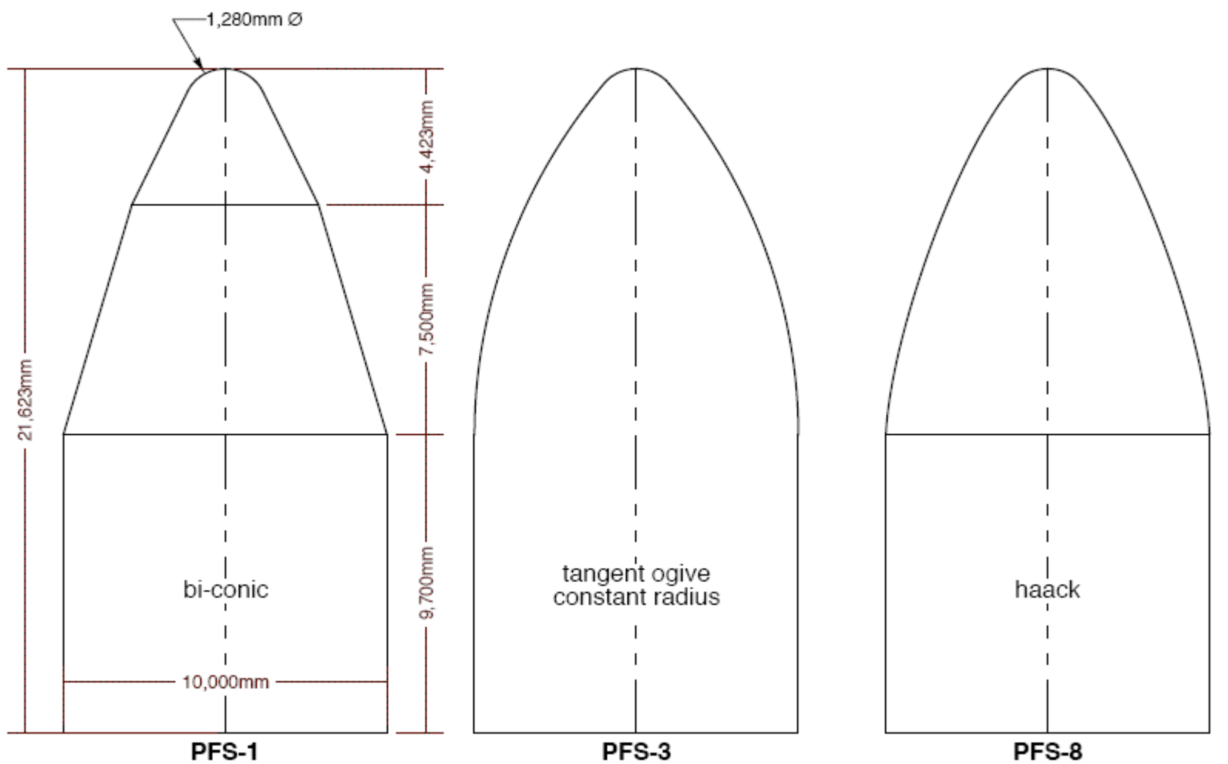
- The figure shows the Lagrange points associated with the Sun-Earth system
- L2 roughly 1.5 million kilometers beyond Earth
- L1, L2, and L3 are unstable, so any spacecraft placed there must do stationkeeping
- Typically insert the spacecraft into a halo orbit about the Lagrange point, such as shown about L2.



Shapes Delivered to MSFC (2/25/08) to Support Upcoming Wind Tunnel Test

Ares V - Payload Fairing Studies

Payload Fairing Study - 1 (PFS-1), PFS-3, PFS-8
wind tunnel shapes
10m diameter



24.Jan.08 lwt3